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(54) IMPROVEMENTS IN AND RELATING TO HEAT EXCHANGE ARRANGEMENTS

(71) We, DROOGTECHNIEK EN LUCHT-BEHANDELING B.V., a Dutch body corporate, of Westrik 17, Prinsenbeek, The Netherlands, do hereby declare the invention, for which we pray that a patent may be granted us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 The present invention relates to heat exchange arrangements.

According to the invention there is provided a heat exchange arrangement comprising an evaporator arranged in heat exchange relationship with a fluid to be cooled, and a closed loop system for feeding coolant to and from the evaporator, the system including a compressor for compressing the coolant in vapour form, a condenser for receiving the compressed coolant from the compressor and operable to liquefy the vapour by cooling, a controllable relief valve for cooling coolant received by expansion, and feeding the coolant to the evaporator, a heat exchanger having a primary side connected to receive liquefied coolant from the condenser and to feed it to the relief valve, and having a secondary side connected to receive coolant from the evaporator and to feed it back to the compressor, a first sensor for providing an indication of the temperature at the outlet of the relief valve and responsive thereto to control the valve in a sense to maintain the temperature at the outlet of the valve at a predetermined level such that none of the fluid to be cooled is caused to fall below its freezing temperature, and regulator means responsive to the state of the coolant in the closed loop system to control the action at the condenser in such a manner that the heating effected in the primary side of the heat exchanger is sufficient to evaporate the coolant completely whereby no liquid coolant is returned to the compressor.

A heat exchange arrangement embodying the invention will now be described, by

way of example, with reference to the accompanying diagrammatic drawing in 50 which:

Fig. 1 is a fluid circuit diagram of the arrangement;

Fig. 2 is a fragment of the circuit of Figure 1 incorporating a modification of 55 the arrangement of Figure 1; and

Fig. 3 is a fragmentary fluid circuit diagram of another one of the arrangements.

As shown in Fig. 1 the arrangement includes a compressor or pump 1 for compressing a cooling medium vapour, for example freon. "Freon" is a Registered Trade Mark. The compressed vapour is fed through a duct 2 to a condenser 3 which is cooled by ambient air directed on the condenser 3 by a blower 4. As a result of cooling the compressed cooling medium vapour is liquefied. The liquefied cooling medium is fed from the condenser 3 through a duct 5 to an intermediate storage vessel 6, an outlet duct 7 from the vessel is connected to a relief valve 8.

Liquid cooling medium upon passing through the valve 8 expands in a choked manner. As a result the medium experiences a temperature drop due to evaporation taking place and withdrawing heat from the cooling medium itself. The cooled mixture which is part liquid and part vapour is fed into an evaporator 9 where the medium is allowed to evaporate completely by absorbing heat from an air flow 10 to be cooled and which is directed to flow in heat exchange relationship with the evaporator. Thereafter the vapourised cooling medium is returned through a duct 11 to the intake side of the pump 1.

The valve 8 is controlled by means of a pressure sensor 12 at the outlet of the valve 8 which acts in a sense to maintain the pressure at the outlet side of the valve at a predetermined value. Since the medium is in the form of a mixture of saturated vapour and liquid, there exists a fixed relationship between the pressure and the temperature, accordingly, by maintaining

the pressure at a predetermined value, this has the effect of maintaining the temperature at a predetermined value too. The predetermined value of pressure is chosen so that the temperature level in the evaporator will not fall by a sufficient amount such that any water vapour present in the air flow 10 will freeze upon contact with the evaporator thereby to reduce the heat transfer efficiency of the evaporator. It will be appreciated that if the evaporator does not cause freezing then neither will any other components of the arrangement.

At high loads when the air flow across the evaporator is high all the cooling medium passing through the valve 8 will be evaporated in the evaporator 9, but at lower loads a mixture of saturated vapour and liquid will leave the evaporator. To prevent the cooling medium reaching the pump in liquid form and so causing possible damage, a heat exchanger 13 is provided having its primary side 13' located in series with the duct 11, and its secondary side 13" in series with the duct 5 between the condenser 3 and the vessel 6.

At higher loads this heat exchanger 13 will act to cool the liquid leaving the condenser 3 by warming up the cooling medium flowing through the primary side 13'. The relative dimensions of the various parts of the arrangement, and in particular those of the condenser 3 and the heat exchanger 13, are chosen so that, at maximum load complete evaporation of the mixture of saturated vapour and liquid is brought about in the primary side 13' of the exchanger 13, before the cooling medium is fed to the pump even to the extent that the cooling medium flow is somewhat superheated.

At lower loads, and in particular at zero load, the liquid content in the primary side 13' of the heat exchanger 13 increases, so that more heat needs to be exchanged to evaporate the liquid. With increasing liquid content, and if the flow rate does not become too low, the heat transfer coefficient will increase, which will increase the heat transfer within the heat exchanger. The transferred heat comes from the compressed vapour in the secondary side 13" of this heat exchanger, so that the latter will supplement the operation of the condenser 3. If a mixture of saturated vapour and liquid is present in the secondary side 13", the heat transfer coefficient will be large at that side too, so that a very efficient exchange will take place, but if the cooling medium is liquefied too much before reaching the heat exchanger 13, then the danger exists that insufficient superheating will occur in the primary side 13', and cooling medium in liquid form will

be discharged from the primary side 13'.

In order to prevent this, the condenser 3 is controlled in such a manner that a greater heat exchange can be achieved in the heat exchanger 13. A regulator 14 is responsive to the pressure sensed in duct 2 by a pressure sensor 15 to control the blower 4. Accordingly with a decreasing load, the temperature in the secondary side 13" of the exchanger will fall as a consequence of the increasing heat transfer. Then so also will the pressure as sensed by the sensor 15 will drop. The blower 4 will, then, be switched off, so that the influence of the condenser 3 will decrease accordingly. The regulator 14 can operate as an on-off regulator, or it can effect a continuous or step-wise velocity control of the blower motor.

In this manner a substantial part of the heat at zero load will be internally exchanged, and the condenser 3 has only to remove the excess of the energy supplied by the pump 1. At such small loads the liquid content in both primary and secondary sides of the heat exchanger will be high, so that the heat transfer coefficient will be high, and a very favourable internal heat transfer will take place. If now the load increases the liquid content in the primary side 13' will decrease, so that the internal heat transfer decreases, and the condenser 3 will become more effective. The condenser 3 is dimensioned so that it can provide the required condensation at maximum load.

In the modification shown in Figure 2 the pressure sensor 15 of Figure 1 is replaced by a temperature sensor which is located to detect the temperature inside the section 11' of the duct 11 lying between the heat exchanger 13 and the pump 11.

In another modification instead of controlling the blower 4, as in Figure 1 the regulator 14 is connected to control 110 throttle valves (not shown) for restricting the air flow to and/or from the blower 4.

If cooling of a fluid medium other than air is desired a controllable circulating pump or controllable throttle valve for this other medium can be used.

In the arrangement shown in Figure 3, a flow restrictor 17 is located between the relief valve 8 and the evaporator 9. In such a restrictor a pressure drop will occur 120 which will increase as the cooling medium flow therethrough increases. The resulting pressure drop is accompanied by a corresponding fall in temperature. This restrictor is adjusted so that, at zero load, the 125 temperature of the air flow 10 will remain above the freezing temperature of the vapour present in the evaporator. At higher loads the cooling medium flow through the restrictor 17 will increase so 130

that the temperature in the evaporator 9 will fall accordingly. Because of the greater temperature difference the heat transfer from the air flow will increase.

5 The flow restrictor 17 is advantageous since because the relief valve 8 maintains a fixed pressure, and therefore a fixed temperature at its outflow side, the variable temperature in the evaporator 9 caused by 10 the flow restrictor 17 is unambiguously tied to the load. The use of the relief valve 8 adjusted to a fixed pressure is possible since the required evaporation and superheating of the cooling medium is ensured.

15 **WHAT WE CLAIM IS:—**

1. A heat exchange arrangement comprising an evaporator arranged in heat exchange relationship with a fluid to be cooled, and a closed loop system for feeding coolant to and from the evaporator, the system including a compressor for compressing the coolant in vapour form, a condenser for receiving the compressed coolant from the compressor and operable to liquefy the vapour by cooling, a controllable relief valve for cooling coolant received, by expansion, and feeding the coolant to the evaporator, a heat exchanger 20 having a primary side connected to receive liquefied coolant from the condenser and to feed it to the relief coolant from the evaporator and to feed it back to the compressor, a first sensor for providing an indication of the temperature at the outlet of the relief valve and responsive thereto to control the valve in a sense to maintain the temperature at the outlet of the valve at a predetermined level such that none of the 25 fluid to be cooled is caused to fall below its freezing temperature, and regulator means responsive to the state of the coolant in the closed loop system to control the action of the condenser in such a manner that the 30 heating effected in the primary side of the heat exchanger is sufficient to evaporate the coolant completely whereby no liquid coolant is returned to the compressor.

40 2. An arrangement according to claim 45

1 wherein the regulator means includes means for discharging heat from the condenser, a second sensor for sensing the pressure or the temperature of the coolant at the compressor and a regulator responsive to the second sensor for controlling the discharge means in dependence thereon.

3. An arrangement according to claim 2, wherein the regulator is arranged to control the operation of the heat discharge means in discrete steps.

4. An arrangement according to claim 2 wherein the regulator is arranged to control the operation of the heat discharge means in a continuous manner.

5. An arrangement according to any preceding claims including a flow restrictor located between the relief valve and the evaporator, the restrictor being set so that at zero load imposed on the evaporator, the temperature of the evaporator will not fall below the freezing temperature of the fluid to be cooled, and at maximum load the temperature of the coolant as a consequence of the larger pressure drop will fall so much that, while maintaining the former condition, the heat transfer at the evaporator due to the larger temperature difference is increased.

6. A heat exchange arrangement substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.

7. A heat exchange arrangement substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.

8. A heat exchange arrangement substantially as hereinbefore described with reference to Figure 3 of the accompanying drawings.

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1578966

COMPLETE SPECIFICATION

1 SHEET

*This drawing is a reproduction of
the Original on a reduced scale*

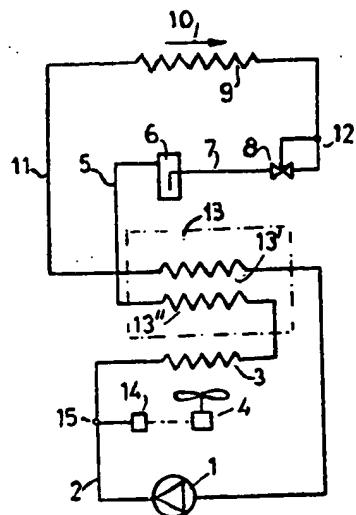


FIG. 1

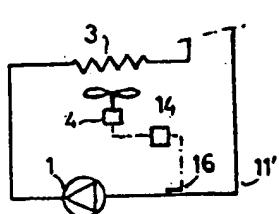


FIG. 2

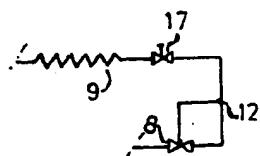


FIG. 3